# Tectono-magmatic origin of the Conrad Rise: Key to understanding the development of the southwestern Indian Ocean during the Late Cretaceous

*Hiroshi Sato[1], Shiki Machida[2], Ryoko Senda[3], Osamu Ishizuka[4], Christine Meyzen[5], Michael Bizimis[6], Taichi Sato[4], Masakazu Fujii[7,8], Yoshifumi Nogi[7,8]

1. School of Business Administration, Senshu University, 2. Ocean Resources Research Center for Next Generation, Chiba Institute of Technology, 3. Faculty of Social and Cultural Studies, Kyushu University, 4. Geological Survey of Japan, AIST, 5. University of Padova, 6. University of South Carolina, 7. National Institute of Polar Research, 8. SOKENDAI

Two major hotspots with age-progressive tracks are observed in the Indian Ocean: the Kerguelen and Reunion hotspots, which are thought as the surface expression of deep-seated mantle plumes related to Large Igneous Provinces (e.g., Coffin and Eldholm, 2014). Between these hotspot tracks, three other hotspots without obvious age progression are present: Marion, Crozet, and Conrad hotspots. The Marion hotspot is a deep-rooted mantle plume (e.g., Marignier et al., 2020; Wamba et al., 2021; Tsekhmistrenko et al. 2021), and several reconstructions have argued for a relationship between volcanic activity and tectonic development since the late Cretaceous. However, the origins and activities of the Crozet and Conrad hotspots remain controversial. We obtained late Eocene $^{40}Ar/^{39}Ar$ age for alkalic volcanic rock from the Ob seamount, western edifice on the Conrad Rise.

Volcanic rocks recovered from the Conrad Rise are divided into three groups in terms of mode of occurrence: massive lava, volcanic breccia, and porous lava. Massive lavas consist of most of the dredged volcanic rocks and exhibit a wide range of major element compositions. The sub-alkalic rocks from basalt to andesite are smaller in volume, while the alkalic rocks from basalt, trachybasalt, tephrite to phonolite are more abundant. The volcanic breccia consists of clasts of volcanic fragments with a calcite matrix. The porous lavas represent a small number of dredged rocks from Ob seamount, but they are the primary lithology at the small seamounts. Compositionally, they are basanite or tephrite in major element classification.

The trace element compositions of the Conrad alkalic volcanics are similar to those from the Kerguelen Plateau and Kerguelen Archipelago volcanics, Prince Edward Islands, and the Crozet Islands. However, their isotopic compositions are distinct. Our data show that the Conrad alkalic volcanics have lower $^{87}Sr/^{86}Sr$ and $^{143}Nd/^{144}Nd$ ratios than those from Kerguelen Archipelago and higher $^{87}Sr/^{86}Sr$ and lower $^{143}Nd/^{144}Nd$ isotope ratios than those from Northern Kerguelen Plateau, contrary to older data (Borisova et al., 1996). They have similar $^{206}Pb/^{204}Pb$ ratios, but the Conrad alkalic rocks have lower $^{207}Pb/^{204}Pb$ and $^{208}Pb/^{204}Pb$ ratios than volcanic rocks from both Kerguelen Archipelago and Kerguelen Plateau. Furthermore, volcanic rocks from the Crozet Islands and the Prince Edward Islands have lower Sr and higher Nd–Pb–Hf isotopic ratios than Conrad Rise.

Homrighausen et al. (2021) concluded that the activity of the Conrad hotspot had formed the southern portion of the 85°E Ridge and eastern Conrad Rise. Based on their plate reconstruction model, the Afanasy Nikitin Plateau and eastern Conrad Rise were emplaced contemporaneously at the past SEIR between ~84 to 75 Ma. Recently, Sato et al. (2022) revealed that the southern Madagascar Ridge and Del Cano Rise formed a single bathymetric high. They began to separate ca. 66 Ma. MacLeod et al. (2017) estimated an extinct spreading axis between the Del Cano and Conrad Rises. Therefore, it is highly plausible that the southern Madagascar Ridge, Del Cano Rise, and Conrad Rise formed a single bathymetric high during the Cretaceous.

Thus, the formation of Conrad Rise was vaguely thought to be in the Late Cretaceous. However, our newly

 

obtained $^{40}Ar/^{39}Ar$ age might indicate younger volcanic activity on the Conrad Rise. These lines of evidence give us new constraints to consider tectono-magmatic evolution in the southern Indian Ocean since the Cretaceous.

Keywords: Conrad Rise, Southern Indian Ocean, geochemistry

 